DOCUMENT RESUME

ED 367 394 JC 940 146

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TITLE Comparison of Effectiveness of Collaborative Learning Methods and Traditional Methods in Physics Classes at Northern Maine Technical College.
PUB DATE Feb 94
NOTE 29p.; Ed.D. Practicum, Nova University.
PUB TYPE Dissertations/Theses - Practicum Papers (043)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Classroom Techniques; Comparative Analysis; *Cooperative Learning; *Lecture Method; Outcomes of Education; *Physics; *Science Instruction; Scores; Teaching Methods; Technical Institutes; Two Year Colleges
IDENTIFIERS Northern Maine Technical College

ABSTRACT

To determine the effect of collaborative learning methods on the success rate of physics students at Northern Maine Technical College (NMTC), a study was undertaken to compare the mean final exam scores of a students in a physics course taught by traditional lecture/lab methods to those in a group taught by collaborative techniques. The traditional group consisted of 18 students and utilized lectures, discussion of assigned readings, in-class discussion of related physics problems, and common laboratory assignments. The collaborative group included 12 students and utilized short lectures and collaborative assignments, tests, and laboratory assignments. The mean final score was calculated for each group and a two-tailed t-test was conducted to test against the null hypothesis that there would be no significant difference between the two groups' mean scores. The traditional group earned a mean score of 19.11, while the collaborative group earned a mean of 18.17. No significant difference was found in student success resulting from the difference in instructional method. Results indicated, however, that collaborative learning methods were as effective as others. The physics final exam is appended. Contains 14 references. (BCY)

COMPARISON OF EFFECTIVENESS OF COLLABORATIVE LEARNING METHODS AND TRADITIONAL METHODS IN PHYSICS CLASSES AT NORTHERN MAINE TECHNICAL COLLEGE

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A Practicum Report presented to Nova University in partial fulfillment of the requirements for the degree of Doctor of Education

Nova Southeastern University

February, 1994

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Terrence H. Overlock, Sr.

January, 1994

In the spring semester of 1993, the number of NMTC associate degree physics students receiving a D or less stood at approximately 35%. The purpose of this study was to determine if collaborative learning methods could increase the success rate of physics students. The research hypothesis was: there will be a significant difference between the mean final exam scores of physics students taught by traditional lecture/lab methods and those taught by collaborative methods.

The mean final exam score for each class was

calculated and a two-tailed t test for independent sample means was conducted and results compared to a rejection region of ± 2.048 at the .05 level of significance with a degree of freedom of 28. The lecture group, numbering 18 students, earned a mean score of 19.11, and the collaborative group, with 12 students, earned a mean of 18.17. The standard deviation of the first group was 9.11 and that of the second group 9.02. The null hypothesis was: there will be no significant difference between the mean final exam scores of physics II students taught by traditional lecture lab methods and those taught by collaborative learning methods. The resulting t value of .28 did not enter the region of rejection of ± 2.048, and the null hypothesis was retained.

There was no significant difference in student success resulting from the treatment, as measured by the average final exam scores, but the results did seem to indicate that collaborative learning methods were as effective as others. Further study and refinement of collaborative teaching techniques were recommended.

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Chapter One

INTRODUCTION

Background and Significance

Northern Maine Technical College (NMTC) had 644 full-time students in the spring of 1993 enrolled in its 19 different occupational programs. The 28% decline in the 18-24 year old group since 1980 (NMRPC, 1993) coupled with the increasing numbers of adults returning for skills updating or retraining has contributed to a rise in the average student age of approximately thirty. This made the student population essentially an adult one.

Physics I and II are algebra and trigonometry based associate degree courses that are required for all trade and technical students working toward an A.A.S. degree. In the spring semester of 1993, the number of students receiving a final grade of D or less, including withdrawals, was approximately 35%. The problem was, lack of success in these courses jeopardized the students' ability to graduate with an associate degree.

Purpose

Recent increased interest in the benefits of collaborative learning techniques in enhancing student success, especially as they apply to adult students, might be a solution to the problem. Hamilton and Hansen (1992, p. 10) say:

> . . . the business community is increasingly acknowledging the need to have workers able to think for themselves in the company of others, and to negotiate alternative paths to success (or alternative solutions to a problem) within a wide range of perspectives and possibilities. Experience with collaborative learning environments at the [postsecondary level] will introduce students to the skills and benefits of working collaboratively.

To this Hulse-Killacky (1990, p. 4) adds:

> If, as a society, we are interested in seriously considering and implementing concepts of empowerment, cooperation, inclusion, and collaboration, then learning to work effectively in groups is a critical ingredient for accomplishing these goals in our educational settings.

Smith (in Hamilton and Hansen, 1992, p. 20 says:

> We need to know exactly what produces effective learning in collaborative pedagogy--the structure, amount, and range of type of response or the sheer time in practice. Whether collaborative learning . . . improves learning more than other techniques--all this is still open to question.

Johnson and Johnson (in Lankard, 1992, p.1) reported that:

> students who participate in cooperative learning groups learning groups realize greater achievement and greater levels of understanding of the subject matter, have an ability to absorb content that requires higher levels of thinking, and are able to retain what they have learned longer.

Bruening (in Lankard, 1992, p. 1) identifies the following five elements of small group learning that are essential to the process: (1) positive interdependence, (2) face-to-face interactions, (3) individual accountability, (4) social skills and, (5) group processing.

The purpose of this project, therefore, was to investigate the effectiveness of collaborative learning techniques in enhancing student success in associate degree physics classes. This was accomplished by comparing the mean final exam scores of physics students taught with collaborative learning techniques with those taught with lecture/lab techniques.

This project is related to the research methodology seminar. A key concept of that seminar was the idea that quasi-experimental research, supported by inferential statistical analysis, could be used to solve institutional problems. In this research project, an inferential methodology was used to address the problem of unsatisfactory success rates of physics students at NMTC. This project utilized the quasi-experimental method because the samples consisted of intact groups determined by the NMTC course registration process.

Research Question

The research question for this research study was: would the mean final exam scores of a physics class taught with collaborative learning techniques be higher than the mean final exam scores of a physics class taught with the lecture/lab method?

Research Hypothesis

The research hypothesis for this study was: there will be a significant difference between the mean final exam scores of Physics II students taught by traditional lecture/lab methods and those taught by collaborative learning methods.

Chapter 2

REVIEW OF THE LITERATURE

With respect to traditional academic skills, Hamilton and Bosworth (1992, in Hamilton and Hansen, p. 22) state that these skills

> focus on individual achievement [and are] not conducive to sharing of ideas and negotiating social reality. . . . Students coming from this paradigm of education will have difficulty being successful in collaborative settings unless skill and attitude comparable with collaboration can be embraced (p. 1).

"According to cognitive theory (Thomas, Johnson, and Anderson, 1992, p. v), learning is a process of knowledge construction rather than knowledge absorption and storage; people use what they already know in constructing new knowledge; and learning is closely related to the context in which it takes place".

> The epistemological implications of the concept that knowledge is a social construct rather than an empirical block of transmittable information are currently resounding throughout the Americas, the United Kingdom, Australia, and New Zealand. Possibilities for restructuring curricula, syllabi and the physical layout of classrooms. . . (Hamilton, 1992, in Hamilton and Hansen, p. 2).

Hamilton (1992) says: "working together results in greater understanding than would likely have occurred had the students worked independently . . . ."

Returning to the classroom can be a difficult experience for adults, especially when learning/ thinking styles developed on the job do not match the learning environment of the classroom. Development of collaborative learning techniques holds promise for effecting a better fit between the classroom learning environment and worker skills sought after by business and industry. Teamwork and collaboration are among the most sought after on the new" skills listed by business and industry. Hamilton (in Hamilton and Hansen, 1992) states:

> . . . the business community is increasingly acknowledging the need to have workers able to think for themselves in the company of others, and to negotiate alternative paths to success (or alternative solutions to a problem) within a wide range of perspective and possibilities. Experience with collaborative learning environments at the [post secondary] level will introduce students to the skills and benefits of working collaboratively (p. 10).

The new expectations of business and industry

> require an integration of individual skills into the group interaction with participants learning about: each other's abilities; what each member has to contribute to the effort; how they can help one another perform better; and, how they can best take advantage of one another's experience" (Lyon, 1990, p. 3).

Bruffee (1987, p. 47) adds that "collaborative learning calls on levels of ingenuity and inventiveness that many students never knew they had. And it teaches effective interdependence in an increasingly collaborative world that today requires greater flexibility and adaptability to change than ever before". Connecting collaborative learning methods to the demands of cultural diversity Agatucci (1989, p. 1) says "collaborative learning strategies can be especially effective in empowering first-year, culturally diverse students to integrate successfully into academic culture and to balance its demands with others students must meet, such as those of family and work".

"While the term collaborative learning encompasses a range of activities, these all utilize cooperative task structures based upon individual learner participation and peer interaction in achieving a common goal" (Harasim, 1991, p. 33). Harisim (1991) also lists the following as activities of collaborative learning: (1) cooperative task structure, (2) shared objective, (3) active participation, (4) peer interaction, (5) shared resources, (6) common goal, and (7) common reward.

Brabson (in Hamilton and Hansen, 1992) feels collaborative learning techniques can enhance the learning environment in college science classes. He and his associates at Indiana University are testing the hypothesis that collaboration is fully appropriate in physics education. He suggests that science educators tap into the collective wisdom and experience of whole language proponents.

Maloney (1992) lists the following advantages to collaborative learning in science classes: (1) it fosters a sense of community; (2) it fosters active reasoning with the concepts and relationships under study; (3) it allows students to ask questions they might not ask in class; and (4) it helps alter students attitudes toward their own abilities in science.

Perhaps the greatest benefit will be the change in role of the faculty member. Maylath (1991) says the role of faculty would be converted, if not reduced, to that of an insightful mentor--a coach who could bring learners to a critical consciousness of the theoretical framework supporting their discussions and activities. Hulse-Killacky (1990) feels instructors serve a key role in this process by setting expectations for open discussion of individual differences, by pointing out that everyone is different, that each person brings a unique perspective to class, and that mutual learning is a goal.

Chapter Three

METHODOLOGY AND PROCEDURES

A search of the literature using the descriptors collaborative learning and cooperative learning was done to identify current research and theory based literature that would contribute to this study. Special emphasis was placed on applications in higher education and science classes.

Data Collection

The population for this study was considered to be all future phyics students at NMTC. The sample for this study was taken from the 1993 fall semester physics students and consisted of class sections A and B. Enrollment in each section was determined by the NMTC course registration procedures used by the registrar's office. Class section A and B of the fall semester 1993 Physics II class were involved in the study.

One section was taught by traditional lecture/lab methods and the other by collaborative methods. The lecture method used in class section A consisted of lecture and discussion of assigned readings, in-class discussion of related physics p oblems, and the usual physics laboratory assignment:

The procedure used with section B included short lectures used to introduce new areas of discussion. Subsequent class assignments, tests, and laboratory activities were done collaboratively. Quizzes were done independently in order to view individual student progress compared to group progress. Groupings of students were established by students with minimal instructor input at the beginning of the semester. These remained the same for the rest of the semester. At the end of the semester, individual students from both groups took the final examination aided by a calculator, and a list of important formulae discussed during the semester.

The content validity of the final exam was assured by constructing the final exam items from word problems previously discussed, but rewritten so as not to be readily recognizable. Each item related to a specific unit objective discussed during the semester. The 42 questions had a total of 55 possible correct answers.

Students had a two hour time limit. Each received one point per correct answer. All scores were entered into the computer based statistics package GB-STAT for statistical processing. A copy of the final exam is included in appendix A.

Data Analysis

The null hypothesis for this study was: there will be no significant difference between the mean final exam score of Physics II students taught by traditional lecture/lab methods and those taught by collaborative learning methods. The alternate hypothesis was: there will be a significant difference between the average final exam scores of Physics II students taught by traditional lecture/lab methods and those taught by collaborative learning methods.

The mean final exam score for each class was calculated, and a two tailed _t_-test for independent sample means was conducted to determine if the difference was significant at the .05 level. As suggested by Issac and Michaels (1990) and Bluman (1992), this test was chosen because the population standard deviation was not known and each sample was smaller than 31. At the .05 level using a degree of freedom of 28, the region of rejection was $\pm$ 2.048.

Definition of Terms

For the purpose of this study, the terms collaborative and cooperative learning were considered to be the same and were defined as: any learning activity that utilized cooperative task structures based on individual learner participation and peer interaction in achieving a common goal.

Assumptions

The following assumptions were made regarding this project: (1) students entering were equally prepared for the study of physics; (2) the class registration process was random; (3) class scheduling had no effect on the results; and (4) the current physics student population will be demographically the same for quite some time into the future.

Limitations

Major limitations of the study were: (1) the results were limited to associate degree trade and technical students in physics at NMTC; (2) the results were limited to the particular collaborative techniques used; and (3) the population chosen could only be applied to studies conducted at NMTC.

Chapter Four

RESULTS

Section A consisted of 18 students. This group was subjected to the usual lecture/laboratory method. Their final exam raw scores ranged from a high of 40 to a low of 7 resulting in a mean final exam score of 19.1 and a standard deviation of 9.10. Section B consisted of 12 students, and was subjected to collaborative learning techniques. The final exam raw scores for this group ranged from a high of 38 to a low of 8 resulting in a mean final exam score of 18.16 and a standard deviation of 9.02. At the .05 level of significance, the region of rejection of ± 2.048 was not surpassed with the calculated *t* value of .28. The results are summarized in table one below.

Table 1

Collaborative Learning Study Results

Group	N	$\bar{x}$	SD	t	df	p @ .05
Sec. A	18	19.11	9.4	.28	28	<> 2.048
Sec. B	12	18.17	9.02			

Therefore, the null hypothesis was retained as true indicating no difference in the performance of the two groups. The alternate hypothesis was rejected.

The number of students receiving a grade of D or less, including withdrawals, was 33%. This was a similar result to the spring 1993 semester in which approximately 35% physics students earned a D or less.

Chapter Five

DISCUSSION, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Discussion

Even though some (Johnson & Johnson in Lankard, 1992) report greater student acheivement resulting from collaborative learning environments the results of this study do not bear this out. However, final conclusions on the value of collaborative learning techniques should not be based on this one study.

If there is no major difference in content area acheivement obtained by this process the value derived may in fact rest with the other desired outcomes previously listed by Hamilton & Hansen, Lyon, Lankard (1992). These include enhanced interpersonal and group communication skills, team skills, problem solving skills, and negotiating skills (Hamilton & Hansen, 1992, and Lyon, 1990), however, these were not the focus of this study.

Linkard (1992, p. 1) says "implementation of coopertive learning strategies requires teacher training and follow-up." Further training and practice with collaborative techniques may favorably impact student content acheivement in physics.

Conclusion

Even though there was no significant difference between the two groups, the study did seem to indicate that collaborative learning techniques were at least as effective as the lecture and laboratory method. The value derived from the process may have been found in gains in the social, communication and other support skills utilized rather than increased content area acheivement. More study should be conducted on the other facets of collaborative learning not looked at in this study.

Implications

Even though there seemed to be no significant difference in the final exam scores of the two groups, the fact that collaborative methods did not adversely affect the learning environment indicates further experimentation with collaborative learning techniques will not adversely affect learning outcomes. Further study aimed at assessing the impact of collaborative learning on communication skills, team skills, higher order thinking skills previously mentioned may show greater value in the process as discussed by Brufee (1987) and others.

Lankard (1992) points out the necessity of teacher training and follow-up when implementing cooperative or collaborative processes. This may suggest that with continued practice and refinement the implementation of a collaborative learning environment may produce higher content area acheivement.

Recommendations

Continued study of the value of collaborative learning methods should be done in all classroom environments at NMTC. A study based on a pretest – post-test design might better assess their impact on student learning. Further enhancement of faculty expertise in the use of collaborative methods should be promoted as these methods seem to foster the kind of classroom environment that more closely approximates the work environment of today.

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Appendix A

Physics II Final Exam Name______________

1. What is the efficiency of a pulley that has an ideal mechanical advantage of 4 and an input force to output force ratio of 0.75?

2. The two pistons of a hydraulic press have diameters of 3 inch and 72 inch. (a) What force must be applied by the smaller piston to give a compressive force of 50 tons at the larger piston? (b) How far does the small piston travel in moving the larger piston 1 inch?

3. A fan produces an increase in static pressure of 2.5 inch (H_2O) and an increase in total pressure of 3.0 inch (H_2O). The flow rate is 3600 ft^3/min. The input horsepower is 2 hp. Determine the static efficiency of the fan.

4. The total weight of skiers and equipment on a ski tow is 5300 lb. The cable of the ski tow pulls this load up an incline of 25^0. What is the tension in the cable if frictional forces are negligible?

5. An impulse turbine wheel is acted upon by a water jet having a velocity of 550 ft/sec and a diameter of 2 inch. The value of $0 = 15^0$ and $f = 0.90$. Find the turbine power when the velocity of the buckets is (a) 75, (b) 175, and (c) 200 ft/sec (assume no additional power losses). (d) What is the jet power?

6. A fan with an input power of 1.0 hp produces a flow rate of 2000 ft^3/min. The increase is 2.6 inch (H_2O). The total efficiency of the fan exceeds the static efficiency by 10%. Determine the total pressure.

7. How much power must be input to a fan to achieve an air horsepower of 7 hp if the mechanical efficiency of the fan is 72%?

8. In a nutcracker (Class II lever), a force of 42 lb is applied 6.5 inch from the fulcrum. What is the force on a nut 1.25 inch from the fulcrum?

9. What is the input current of an ideal transformer if the ideal mechanical advantage is 6 and the output current is 0.2A?

10. The ideal mechanical advantage of a hydraulic lift is 5. What is the ratio of the radius of the piston on the load side to that of the source piston?

11. The output piston of an ideal hydraulic system does 100 J of work by moving 20 cm. How far does the input piston move if the ratio of the area of output piston to the input piston is 3 to 1?

12. A jet of water moving in the direction of the x axis strikes a body moving in the same direction. The velocity of the object is 65 ft/sec. The angle of the jet leaving the body (0) is 25^0 and f is 0.95. Find the force acting on the body in the x direction. V_{IX} = 100 ft/sec. A = .00645 ft^2

13. If a load of 1000lb is moved through 21 inches on the input piston, how much load will it lift on the output piston if the input piston diameters are 1 and 12 inch respectively? How far will the 12-inch output piston diameters move during this process?

14. A wheelbarrow containing sand weighs 550 lb. If the distance from the center of gravity to the axle of the wheel is 1.5 ft, and the distance from the handle to the axle of the wheel is 5 ft, what lifting force must be applied at the handle to lift the load?

15. What is the required input force to the source wheel of a wheel and axle if the circumference of the load wheel is 0.25 and the radius of the drive wheel is 0.5m, when the load is 30 N?

16. A wheel and axle is used to lift a 2400-lb load. The wheel diameter is 60 inches and the axle diameter is 5 inches. The operator must exert a force of 250 lb to lift the load.

Determine:

A. Ideal mechanical advantage
B. Actual mechanical advantage
C. Efficiency of the transformer

17. What force must be applied to a pulley with an efficiency of 85% if the load force is 400 N and the ideal mechanical advantage is 3?

18. A certain thin-walled circulate piston is made of a material that can withstand up to 10,000 lb/ft^2 before it fractures. What is the maximum force this piston can withstand before it fractures if the piston's diameter is 3 inches?

19. The inductance of the primary coil of an ideal transformer is 5.0 H. If the frequency of the applied voltage is 60 HZ and the root-mean-square voltage is 120V, (a) what is the primary current when the secondary circuit is open? (b) When a load resistance of 100,000 ohms is connected across the secondary coil? The inductance of the secondary coil is 1.0 H.

20. If an ideal transformer has N_p = 4000 turns, N_s = 600 turns, and R_L = 50 ohms, what are the primary and secondary currents if V_p = 100V? Assume the 100% efficiency and a power factor ratio of one.

21. How much fluid is displaced on the source side of a hydraulic lift if the load piston has a cross-section area of 0.5 m^2 and is raised 10 cm?

22. What is the cross-section area of the source in Problem 21 if the lift has an ideal mechanical advantage of 12?

23. What is the primary current of an ideal transformer if the primary voltage is 24 V, the power output is 300 W, and the power factor is unity?

24. An ideal transformer has V_p = 12 V and V_s = 3 V. Calculate the turns ratio.

25. A screw jack is being used to lift a load of 5 tons. The screw pitch is 0.25 inch and the handle length 30 inch. (a) In the ideal case, what force is needed at the end of the handle? (b) If the efficiency is 35%, what force is needed?

26. What is the ideal mechanical advantage of a plane inclined at an angle of 35°?

27. An ideal transformer with a power factor ratio of unity has $N_p = 500$ turns, $N_s = 1250$ turns, $V_p = 12$ V, and $I_p = 0.6$ A. Calculate I_s and V_s.

28. A 15° wedge is used to separate two pieces of wood. The driving force of 55 lb produces a splitting force of 300 lb. What is the efficiency of the wedge?

29. The ideal mechanical advantage of a pulley is used to predict the need for a 25-N input force. What input force is actually needed if the pulley has an efficiency of 75%?

30. A simple gear drive consists of two gears having 30 and 6 teeth, respectively. If the gear with 6 teeth develops a torque of 0.5 N m, what torque does the other gear develop if friction is negligible?

31. What is the maximum load that can be pushed up an inclined plane that has an ideal mechanical advantage of 5 if the applied force is 65N?

32. What is the lever arm of the input force for a lever with an ideal mechanical advantage of 8 and a load lever arm of 6 inch?

33. In a belt drive system for a bandsaw, the motor has a pulley with a diameter of 2.5 inch and the load has a pulley with a diameter of 12 inch. What is the ideal mechanical advantage of the system?

34. A 15° wedge is driven with a total force of 100 N. What is the ideal splitting force? (The wedge angle is 20 = 12°.)

35. (a) What is the angle of inclination of a plane if the ratio of output work is 0.8 and the ratio of input force to output force is 0.4? (b) Is there friction in this system? (c) How can one tell?

36. In a gear drive system, the large gear has a diameter of 45 cm and a total of 72 teeth. (a) How many teeth does the small gear have if it has a diameter of 5 cm? (b) What is the ideal mechanical advantage of the system?

37. A Class I lever is used to lift a 525-lb block. If the lever is 90% efficient (under all conditions), what is the minimum applied force that the lever must be able to withstand if it is to be used to lift the block? The load lever arm is 1 ft and the lever arm of the applied force is 4 ft.

38. A lever can be used to lift a 300-kg mass when the input force is 350 N. If the ideal mechanical advantage of the lever system is 9, what is the efficiency of the system?

39. The disk drive of a turntable has three disks with diameters of 8.5, 1.15, and 0.1065 inch. What is the ideal mechanical advantage of the system?

40. The input torque of the motor in the turntable in Problem 39 is 0.42 inch-ounces and the turntable is rotating a 33 1/3 rpm. Find the output torque and the angular velocity of the motor if friction is neglected.

41. In a machine for throwing clay targets, a force of 260 lb is applied to a lever 5 inches from the fulcrum. What force is experienced by the clay target 24 inches from the fulcrum?

42. A 125 lb boy sits on a seesaw 5 ft from the pivot. How far from the pivot must an 85 lb girl sit to balance him?